



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

2856

In re: Application of BATEMAN ET AL.)

) Art Unit: 2856

Serial Number: 09/995,662)

) Examiner: N/A

Filed: November 29, 2001) Atty Docket: DEH009

For: MASS SPECTROMETERS AND METHODS OF MASS
SPECTROMETRY#5 | Priority
Paper
5-16-02
RatelenTHE COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

Sir:

The below identified communication(s) or document(s) is(are) submitted in the above application or proceeding:

☒ Priority Document(s) 4☐ Issue Fee Transmittal☐☐ Check in the Amount of \$☐☐ Assignment☐☐ Associate Power of Attorney☐ Please charge Deposit Account Number 04-1075 for any deficiency or surplus in connection with this communication.
A duplicate copy of this sheet is provided for use by the Deposit Account Branch.RECEIVED
FEB - 7 2002
TC 2800 MAIL ROOM

Respectfully submitted,

Everett G. Diederiks, Jr.
Attorney for Applicant
Registration Number: 33,323

Date: February 5, 2002

THIS PAGE BLANK (USPTO)



INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

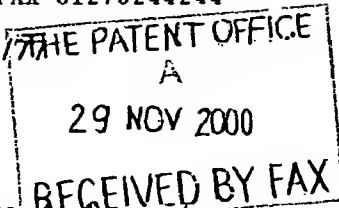
Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed *Andrew Gensay*
Dated 19 DEC 2001

THIS PAGE BLANK (USPTO)

Patents Form 1/77

Patents Act 1977
(Rule 16)



The
Patent
Office

1/77

29NOV00 5587606-1 000027
F01/7700 0.00-00000000.2

The Patent Office
Cardiff Road
Newport
Gwent NP9 1RH

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1. Your reference	85.74444		
2. Patent application number (The Patent Office will fill in this)	29 NOV 2000		
3. Full name of the applicant (Enter all surnames)	Micromass Limited Floats Road, Wythenshawe Manchester, M23 9LZ United Kingdom		
Patents ADP number (if you know it)	6996102001		
If the applicant is a corporate body, give country/state of incorporation	United Kingdom		
4. Title of the invention	Ion tunnel		
5. Name of your agent (if you have one)	Frank B. Dehn & Co.		
"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)	179 Queen Victoria Street London EC4V 4EL		
Patents ADP number (if you know it)	166001 ✓		
6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number	Country	Priority application number (if you know it)	Date of filing (day / month / year)
7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application		Date of filing (day / month / year)
8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))	Yes		

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form

-

Description

4

Claim(s)

-

Abstract

-

Drawing(s)

5 only

10. If you are also filing any of the following, state how many against each item.

Priority documents

-

Translations of priority documents

-

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

-

Request for preliminary examination and search (Patents Form 9/77)

-

Request for substantive examination (Patents Form 10/77)

-

Any other documents (please specify)

-

11.

I/We request the grant of a patent on the basis of this application.

Signature

Date 29 November 2000

12. Name and daytime telephone number of person to contact in the United Kingdom

P.M. Jeffrey
01273 244200

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s) of the form. Any continuation sheet should be attached to this form.
- If you have answered 'Yes', Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- For details of the fee and ways to pay please contact the Patent Office.

Ion Tunnel

Background and Prior Art

The use of rf only multipoles for transport, focussing and trapping of ions as well as conversion of discontinuous ion beams to continuous ones when used in higher pressure vacuum stages is well established and subject of several patents. A less well known rf device for collimating or trapping ions uses a stack of ring electrodes and was first developed to trap ions for the study of ion-molecule reactions or laser interactions with ions. A later development of the ring electrodes employs a stack with decreasing internal diameter to collimate, concentrate and transport ions through a high-pressure vacuum stage.

The first ring electrode device was developed in 1969 by Teloy and Bahr¹ to study thermal rate coefficients of ion-molecule interactions. Further enhancements to the approach are summarised in the review paper by Gerlich². The ring electrode device is made from a stack of metal plates or rings along an axis perpendicular to the central apertures and with fixed spacing. An rf voltage is then applied with 180° phase shift on adjacent plates which generates a effective potential along the axis which has a broad minimum in the radial direction but increases rapidly (exponentially) in the proximity of the electrodes. The field acts to contain ions to the central, low potential, region of the device. In the presence of a sufficient buffer gas in the assembly, ion kinetic and internal energy can be quenched essentially to that of the buffer gas. Consequently, in a typical experiment ions are injected and trapped in the ring electrodes where they undergo collisions with the buffer gas and/or a reagent gas. After a certain reaction time an extraction field is applied and the ions mass analysed and detected. This process is repeated for various trapping times to obtain a reaction rate coefficient.

A more recent manifestation of the ring electrode device has been pioneered by Smith and co-workers at Battelle³⁻⁷ to efficiently transport and focus ions in the relatively high pressure (1-10 Torr) vacuum stages of mass spectrometers operating with API sources. This device uses a stack of ring electrodes with continually decreasing aperture size to provide a large acceptance angle followed by focussing/collimation of the ion beam to a small diameter suitable for passage through a differential aperture into the next vacuum stage of the instrument. In this design, the rf is applied in the same manner as above to adjacent plates, but additionally a dc voltage gradient is provided along the axis of the 'tunnel' to force the ions in the direction of the smaller apertures.

In the Smith group's latest design of ion funnel⁷ a region of plates with constant aperture diameter has been added to the entrance of the ion funnel to reduce the gas dynamic effects upon ion confinement, to improve conductance for pumping, reduces gas load downstream and provides an extended ion residence time for enhanced desolvation.

In a recent publication by Smith and co-workers⁸ the ring electrode device is considered with constant internal diameter apertures with regard to trapping properties

compared to standard multipole assemblies. This paper deals only theoretically with the trapping properties of these devices.

A recent patent application⁹ deals with the use of a tapered ring electrode device with changing aperture shape to modify an ion beam shape prior to entry into an oa-ToF mass analyser. This device is reported to improve resolution in the analyser through reduction of the beam dimension in the time-of-flight direction. In addition, use of the device for ion fragmentation is also reported.

Present Design and Application

We have built a ring stack device with constant diameter apertures for use in the millibar vacuum region of the Quattro Ultima currently occupied by hexapole 1. This 'ion tunnel' directly replaces hexapole 1 and is used to guide/collimate/focus ions from the source block to the vacuum stage containing the second hexapole.

At present the tunnel uses plates of 5mm internal diameter spaced by 1mm and overall is around 125mm in length. The rf is supplied by a standard generator operating at 750 kHz with peak-to-peak voltages in the range of 0 to 350V. No dc voltage gradient is currently applied along the axis of the device however the facility to float assembly to a fixed voltage is available.

This ion tunnel appears to be at least as efficient as the standard hexapole for transmission of ions. Improvements in transmission, particularly at low mass have been realised through use of a source block with the extraction 'cone' replaced by a tunnel, possibly as a result of collimation of the gas/ion stream closer to the axis of the ion tunnel.

Further embodiment:

Continuous ion tunnel between different pressure regions with one or more lens plates forming a differential pumping aperture to improve ion transmission.

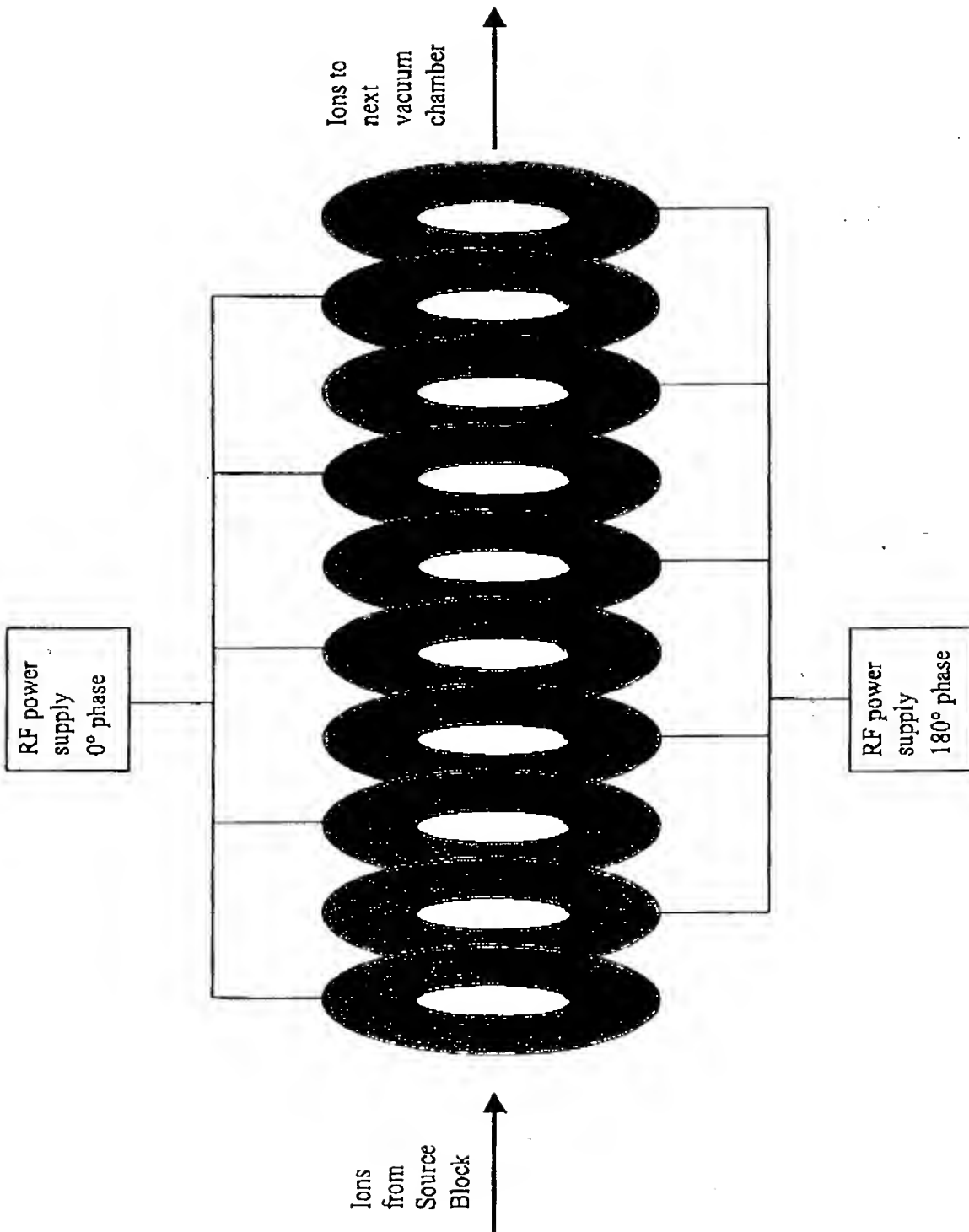
References

- 1) Bahr R, Gerlich D and Teloy E, (1969) Verhandl. DPG (VI) 5, 131
- 2) Gerlich D, in State Selected and State to State Ion Molecule Reaction Dynamics, Part 1: Experiment. Eds CY Ng and M Baer, Advances in Chemical Physics Series, Vol. LXXXII, 1992. Wiley. Pages 93-99.
- 3) Patent US6107628, 'Method and Apparatus for Ion and Charged Particle Focusing', Smith RD, Tang K and Anderson GA. 1997.
- 4) Shaffer SA, Teng K, Anderson GA, Prior DC, Udseth HR and Smith RD, Rapid Commun. Mass Spectrom, 11 (1997) 1813-1817
- 5) Shaffer SA, Prior DC, Anderson GA, Udseth HR and Smith RD, Anal. Chem., 70 (1998) 4111-4119
- 6) Shaffer, SA, Tolmachev A, Prior DC, Anderson GA, Udseth HR and Smith RD, Anal. Chem., 71 (1999) 2957-2964
- 7) Kim T, Tolmachev AV, Harkewicz R, Prior DC, Anderson GA, Udseth HR, Smith RD, Bailey TH, Rakov S and Futrell JH, Anal. Chem., 72 (2000) 2247-2255
- 8) Tolmachev AV, Udseth HR and Smith RD, Anal. Chem., 72 (2000) 970-978
- 9) Jolliffe C and Thomson B, Patent application 'Mass Spectrometer with Tapered Ion Guide' 1998 (internal ref. No. 12804)

- (G) An illustrative schematic of the electrodes and supplies for the RF-only ion tunnel
- (H) An illustrative schematic of one of our existing arrangements with an atmospheric pressure ion source, where we use two RF-only hexapoles to transport ions through regions of relatively high pressure – where (pressure x path length) > 0.01 mbar-cm.
- (I) An illustrative schematic of a similar arrangement where the first of the two RF-only hexapole lenses is replaced by an RF-only ion tunnel to transport ions through a region of relatively high pressure – where (pressure x path length) > 0.01 mbar-cm.
- (J) An illustrative schematic of a similar arrangement where both the RF-only hexapole lenses are replaced by two RF-only ion tunnels to transport ions through regions of relatively high pressure – where (pressure x path length) > 0.01 mbar-cm.
- (K) Manufacturing drawing of the Ion Stack Assembly actually used in our prototype ion tunnel design.

Please note that these sketches illustrate schemes for transporting ions from an atmospheric pressure ion source through to a quadrupole mass filter. The device could be used to transport ions from a variety of different ion sources, including pulsed ion sources such as matrix assisted laser desorption ionisation (MALDI), and into a variety of different mass analysers, including time-of-flight mass spectrometers.

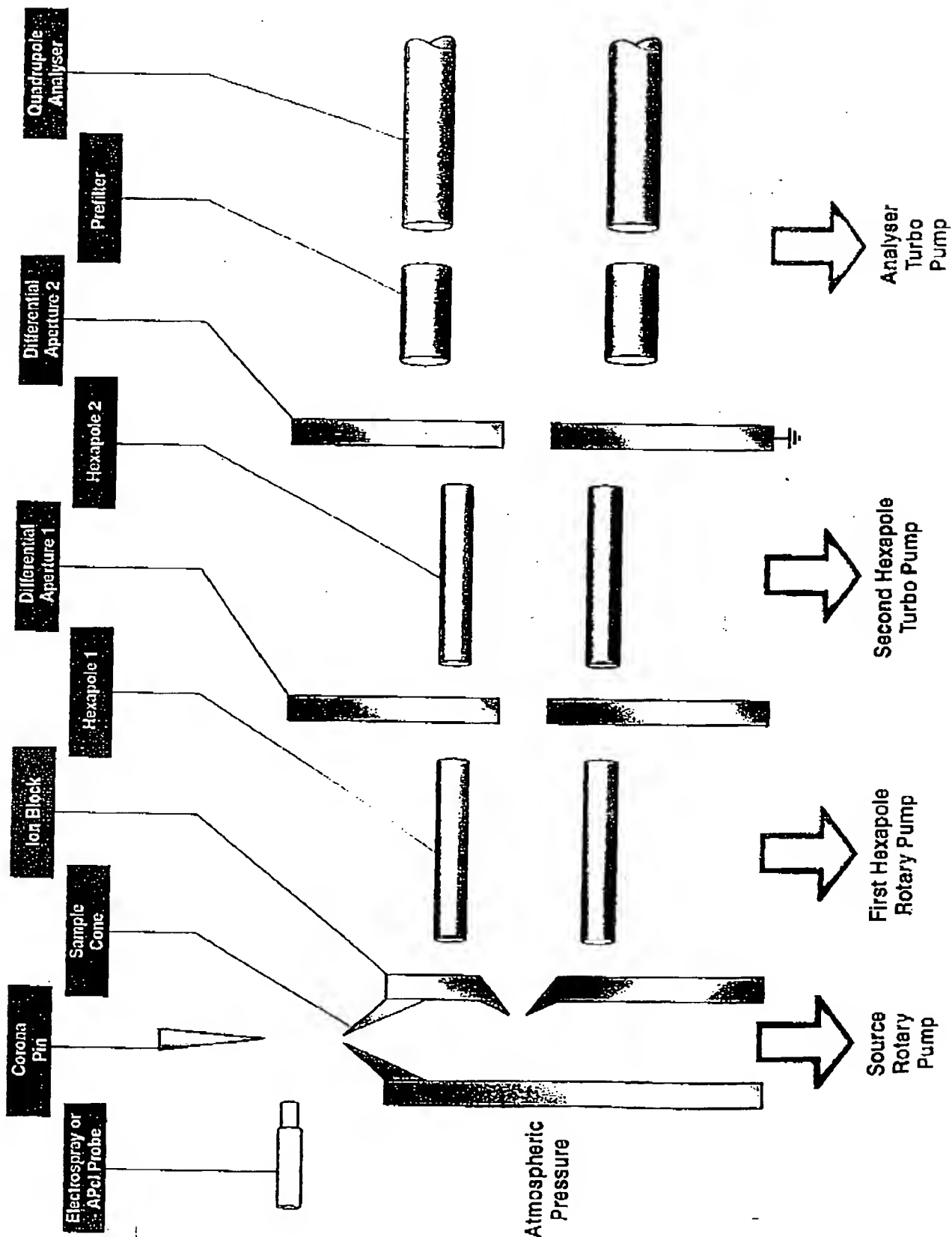
Ion Tunnel Schematic



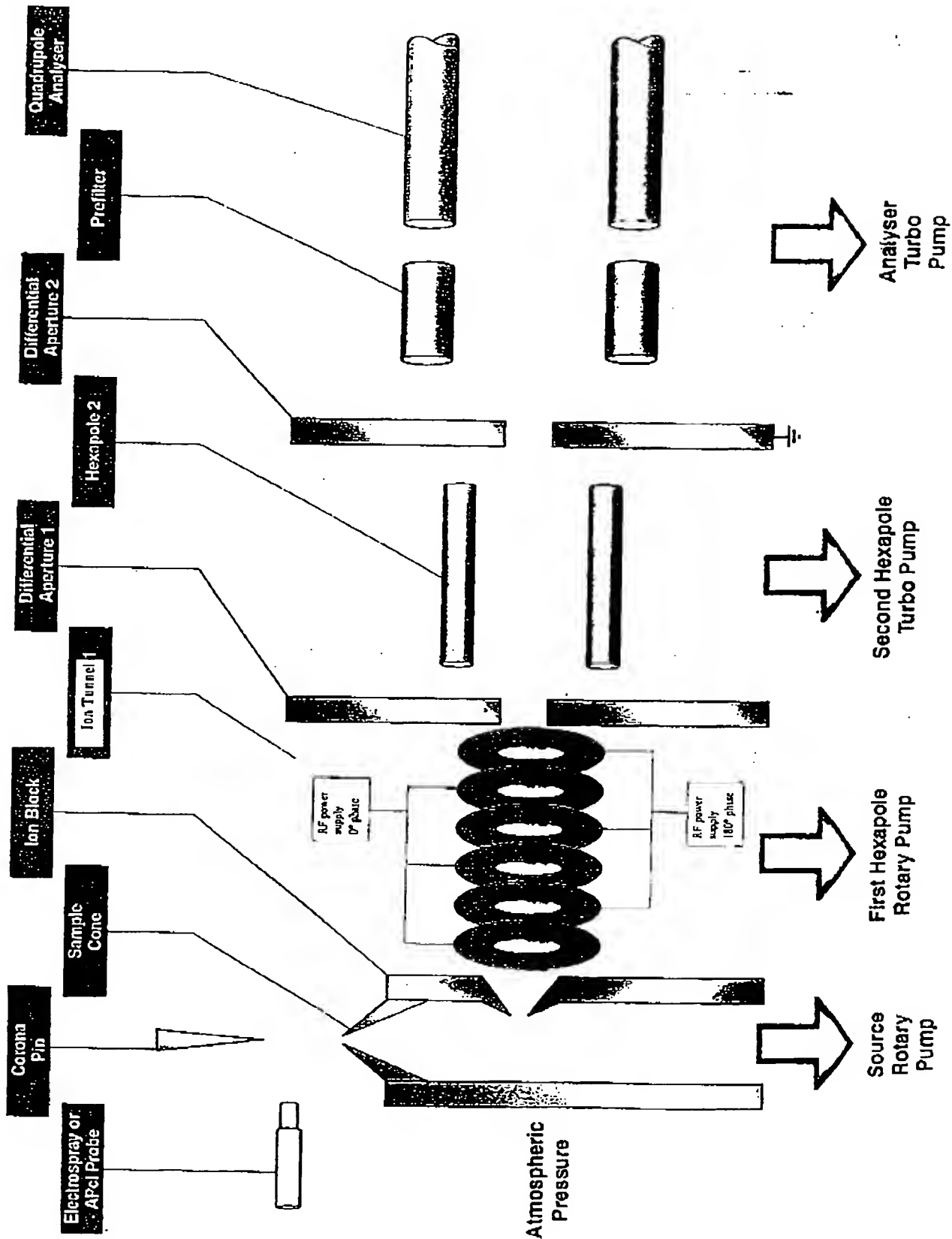
(5)

5

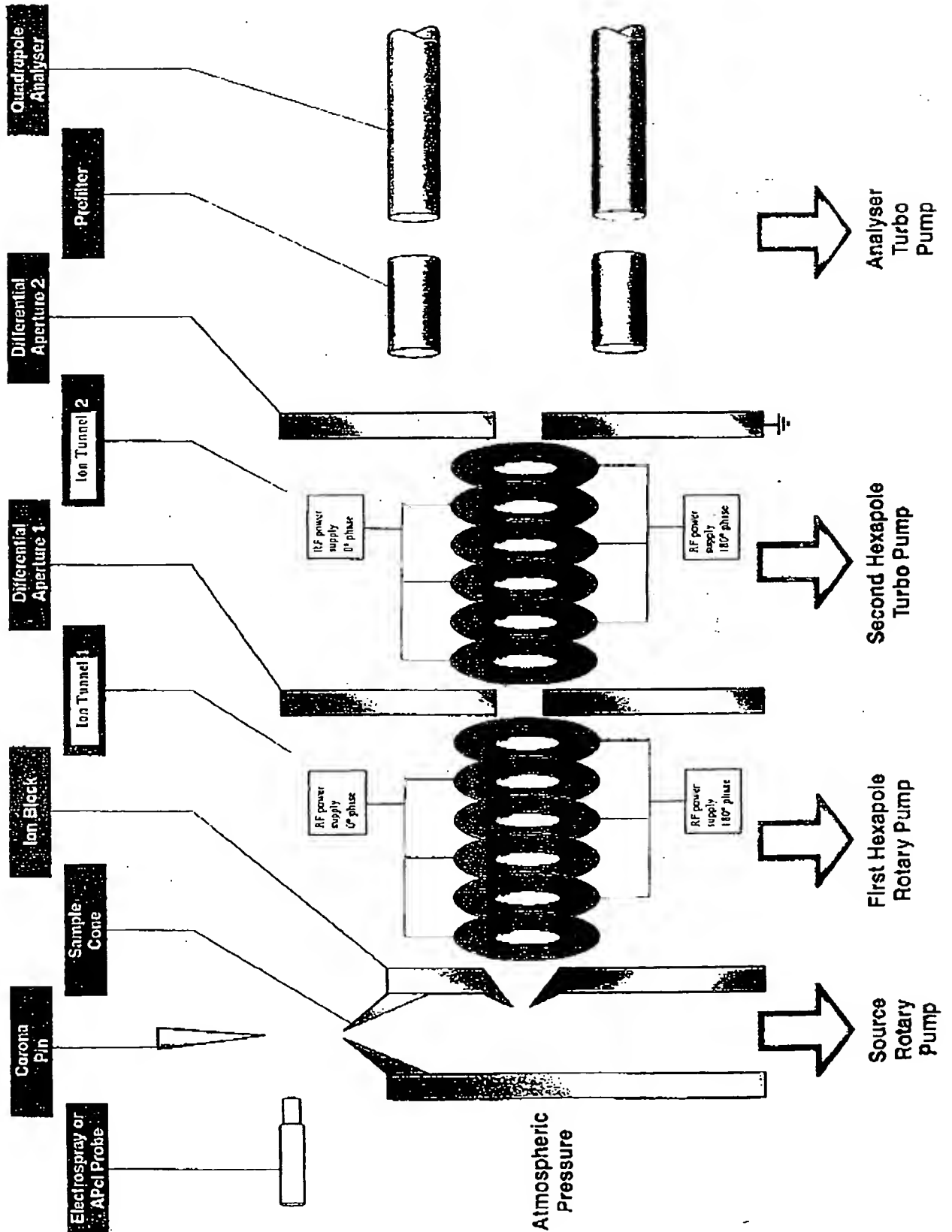
THIS PAGE BLANK (USPTO)



THIS PAGE BLANK (USPTO)



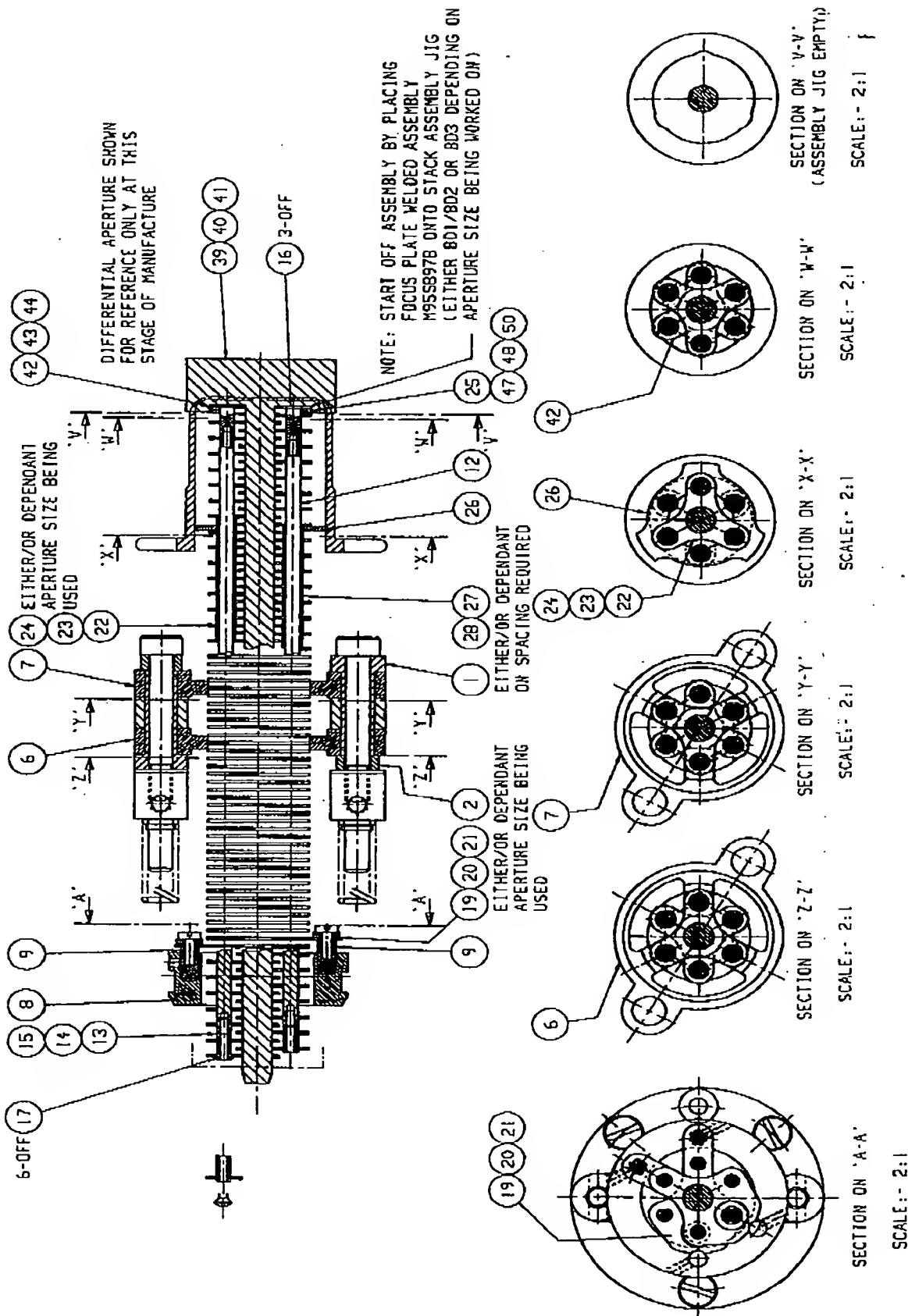
THIS PAGE BLANK (USPTO)



5

8

THIS PAGE BLANK (USPTO)



THIS PAGE BLANK (USPTO)